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RESEARCH MEMORANDUM

AERODYNAMIC CHARACTERISTICS OF A MODEL OF AN ESCAPE CAPSULE FOR A SUPERSONIC BOMBER-TYPE AIRPLANE AT A MACH NUMBER OF 2.49

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS
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AERODYNAMIC CHARACTERISTICS OF A MODEL OF AN ESCAPE CAPSULE FOR A SUPERSONIC BOMBER-TYPE AIRPLANE AT A MACH NUMBER OF 2.49

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SUMMARY

A brief investigation of the aerodynamic characteristics of a model of an escape capsule, with and without stabilizing fins, for a supersonic bomber-type airplane was made in the Unitary Plan wind tunnel at the Langley Laboratory. The escape capsule consisted of a portion of the airplane fuselage extending from just forward of the cockpit canopy to approximately the wing leading edge. The fins were contoured to conform to the shape of the fuselage from which the capsule would be ejected. The data were obtained at a Mach number of 2.49 and a Reynolds number of 1.5×10^6 (based on capsule length) over a range of angle of attack at zero angle of sideslip and over a range of angle of sideslip at several angles of attack. Lift, drag, and longitudinal and lateral stability characteristics as well as typical schlieren photographs of the capsule model with and without stabilizing fins are presented without analysis or discussion.

INTRODUCTION

The problem of getting the crew safely out of an airplane in case of an emergency is quite difficult when ejection must take place at supersonic speeds. One proposed solution for this problem is a sealed escape capsule housing the entire crew which may be separated from the airplane as a unit by means of small rockets. After ejection, the capsule should safely decelerate to a speed at which parachutes could be used for landing the capsule. Presumably, the crew might be in a state of shock during deceleration, so that the capsule should be aerodynamically stable throughout its Mach number range of operation. The design of such an escape capsule is complicated by the fact that any stabilizing fins must fair into the lines of the parent aircraft and must be automatically extended shortly after ejection has taken place.

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Obviously, the aerodynamic characteristics of such an escape capsule should be carefully determined to make sure the severe requirements regarding stability and deceleration rate are met.

An investigation of the aerodynamic characteristics of an escape capsule, with and without stabilizing fins, for a supersonic bomber-type airplane was made in the Unitary Plan wind tunnel of the Langley Laboratory. The data were obtained at a Mach number of 2.49 and a Reynolds number of 1.5×10^6 (based on capsule length) over a range of angle of attack at zero angle of sideslip and over a range of angle of sideslip at several angles of attack. Lift, drag, and longitudinal and lateral stability characteristics as well as schlieren photographs of the capsule model with and without stabilizing fins are presented without analysis or discussion.

SYMBOLS

The systems of axes used in this investigation are shown in figure 1; the moment coefficients are referred to the center of gravity of the model as shown in figures 1(b) and (2).

A	maximum cross-sectional area, 0.1088 sq ft
b	capsule length, ft
C_D	drag coefficient, for $\beta = 0^\circ$, $-X/qA$
C_L	lift coefficient, $-Z/qA$
C_l	rolling-moment coefficient, M_X/qAb
C_m	pitching-moment coefficient, M_Y/qAb
C_n	yawing-moment coefficient, M_Z/qAb
C_Y	side-force coefficient, Y/qA
M	free-stream Mach number
M_X	moment about X-axis, ft-lb
M_Y	moment about Y-axis, ft-lb

M_Z	moment about Z-axis, ft-lb
p	free-stream static pressure, lb/sq ft
q	free-stream dynamic pressure, $0.7pM^2$, lb/sq ft
X	force along X-axis, lb
Y	force along Y-axis, lb
Z	force along Z-axis, lb
α	angle of attack referred to body reference line, deg
β	angle of sideslip referred to body center line, deg

Subscripts:

w	refers to stability axis when used with C_n or β
s	refers to stability axis when used with C_l
B	refers to body axis when used with β

APPARATUS

The tests were conducted in the high Mach number test section of the Langley Unitary Plan wind tunnel, which is a variable-pressure return-flow tunnel. The test section is 4 feet square and is approximately 7 feet in length. The nozzle leading to the test section is of the asymmetric sliding-block type which permits a continuous variation of Mach number from approximately 2.3 to 5.0.

The sting-type model support used in the tunnel is attached to a horizontal strut extending from wall to wall just downstream of the test section. The sting support may be traversed across the tunnel, and the angle of the sting with respect to the longitudinal axis of the tunnel may be varied. In addition, a remotely operated adjustable angle coupling permits variation of the model angle of attack concurrently with variation in the angle of sideslip.

The model was mounted to the sting support through a six-component strain-gage balance located within the model. Details of the model are shown in figure 2, and a photograph of the model is presented as figure 3. The escape capsule consisted of a portion of an airplane fuselage extending from just forward of the cockpit canopy back to approximately the wing leading edge. The fins, which have flat-plate sections with a beveled leading edge, are contoured to conform to the shape of the fuselage from which the capsule would be ejected. The upper fins form the contour of the upper portion of the fuselage when they are in the retracted position, and the fixed lower fins are an integral part of the fuselage before ejection.

TESTS

The model with and without stabilizing fins was tested in an erect position for most positive angles of attack and in an inverted position for most negative angles of attack. In this way, the angle of attack ranged from approximately -1° to 20° and from 1° to -20° for zero angle of sideslip. In order to obtain the maximum sideslip range, the model was oriented with the Y-axis vertical. Most of the positive angles of sideslip were obtained and then the model was rotated 180° to obtain most of the negative sideslip angles. In this way, the angle of sideslip ranged from approximately -1° to 22° and from 1° to -22° for constant angles of -5°, 0°, 5°, 10°, and 20°.

All tests were made at a constant average Mach number of 2.49, and the maximum deviation of local Mach number in the portion of the tunnel occupied by the model was ±0.025 from this average value. The Reynolds number for the tests was approximately 1.5×10^6 based on the capsule length (24.16 inches). Approximate values of the other test conditions are: stagnation pressure, 18 pounds per square inch absolute; stagnation temperature, 150° F; and dynamic pressure, 700 pounds per square foot. The dewpoint for all tests was maintained below -30° F to prevent adverse condensation effects.

CORRECTIONS AND ACCURACY

The tunnel, as yet, has not been completely calibrated, and any flow angularity that may exist in the test section has not been determined. Pressure gradients in the region of the model have been determined and are sufficiently small so as not to induce any buoyancy effect on the model. The drag coefficients have been corrected for base pressures which were measured during the tests. The estimated accuracy of the force and moment coefficients, based on the strain-gage-balance calibrations and repeatability of the data, is within the following limits:

C_D . . . . ±0.001
C_L . . . . ±0.002
C_l . . . . ±0.0002
C_m . . . . ±0.001
C_n . . . . ±0.0005
C_Y . . . . ±0.0015

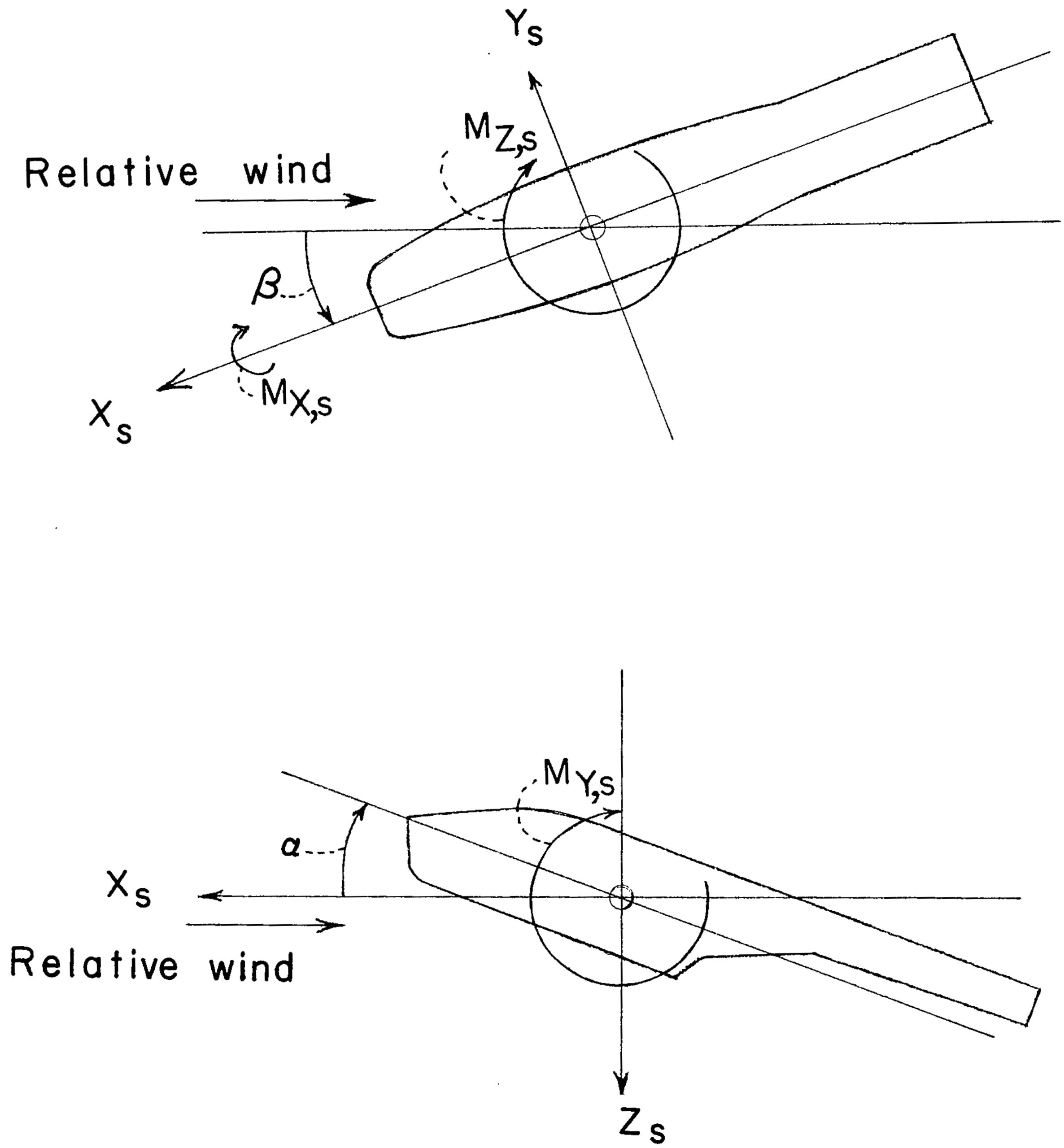
PRESENTATION OF RESULTS

All data are presented about the stability system of axes and the lateral data are also presented about the body system of axes. The results of the investigation are shown in the following figures:

CONCLUDING REMARKS

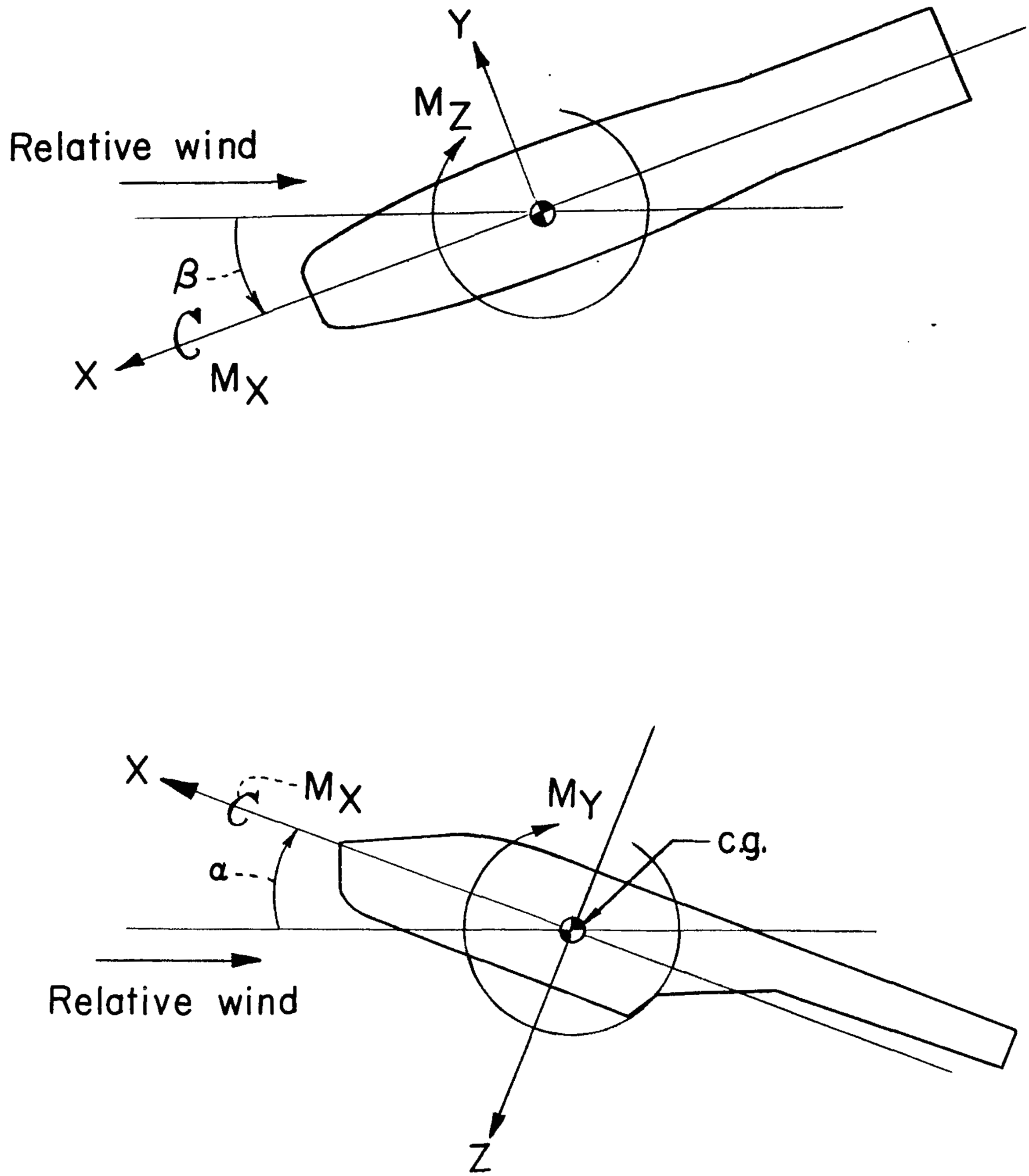
The data indicate that the escape capsule with fins is statically stable at a Mach number of 2.49 for the range of angle of attack and sideslip from -20° to 20°. This stability is derived from the fins rather than from the capsule-body shape since the capsule without fins is unstable. Figure 5 shows that for a given lift coefficient, say 1.2, the drag of the capsule is lower with the fins on than with the fins off. However, the angle of attack required to produce this lift is higher for the capsule with fins off than with the fins on. At a lift coefficient of zero, the angle of attack is about the same for the capsule with fins either off or on, and at this angle of attack the fins cause a slight increase in the drag coefficient. At the very low values of angle of attack, a slight discrepancy may be noted in the values of lift coefficient (see fig. 5). This discrepancy is believed to be the result of an error in angle setting when the model was rotated from an erect position to an inverted position.

Langley Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., August 29, 1957.



(a) Stability axes.

Figure 1.- System of axes used in the investigation. Arrows indicate positive directions of forces, moments, angles, and relative wind.



(b) Body axes.

Figure 1.- Concluded.

[redacted]

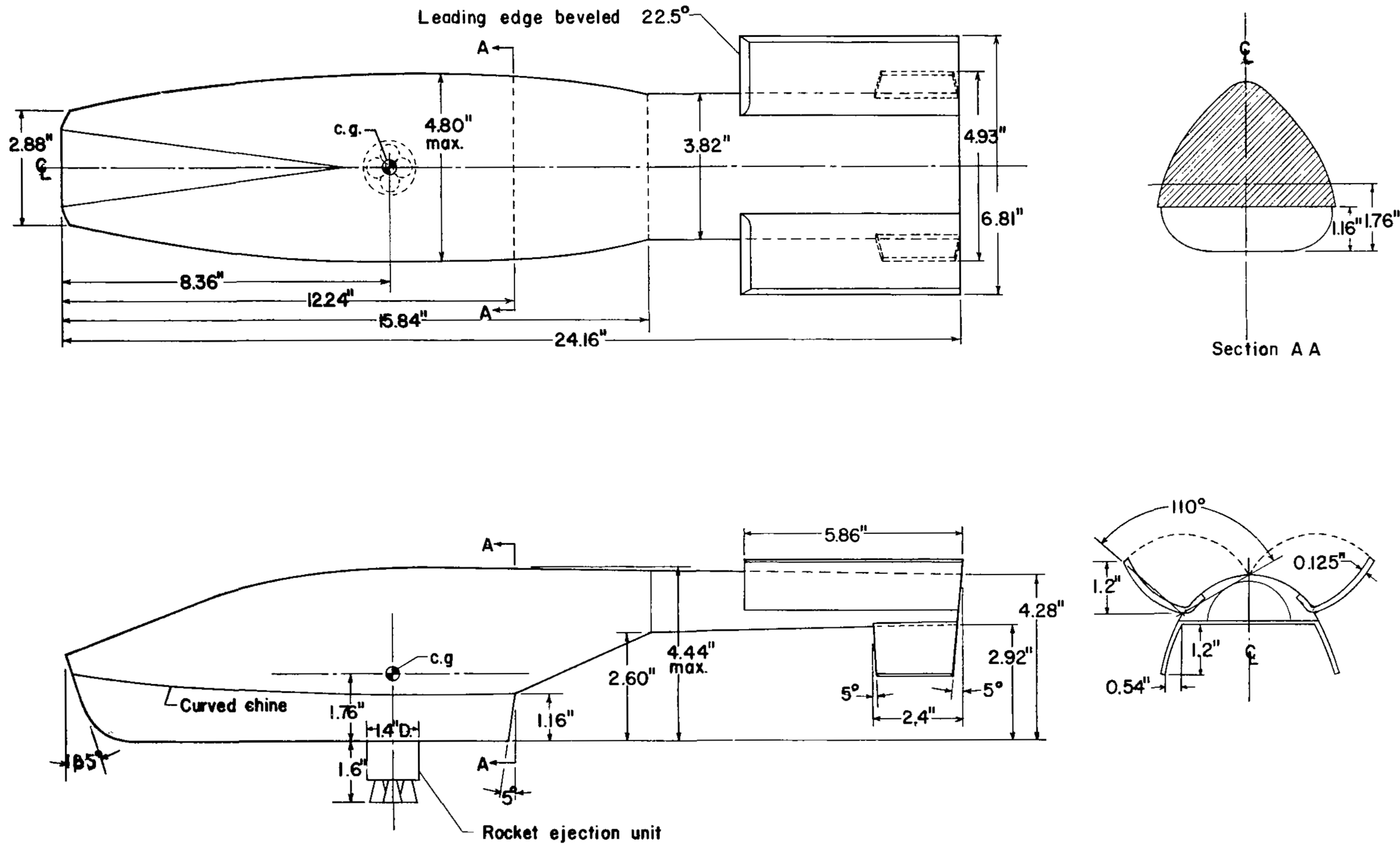
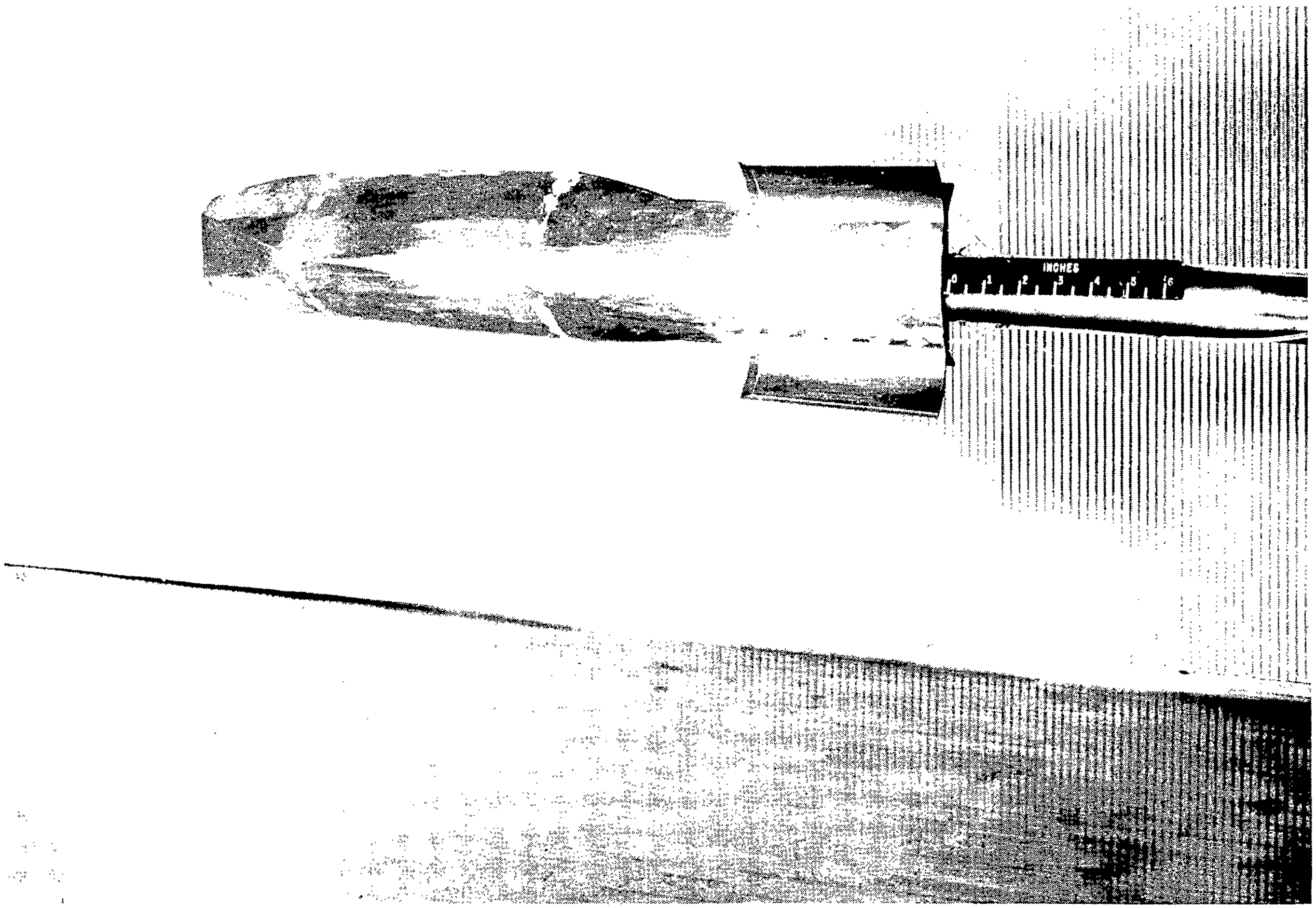
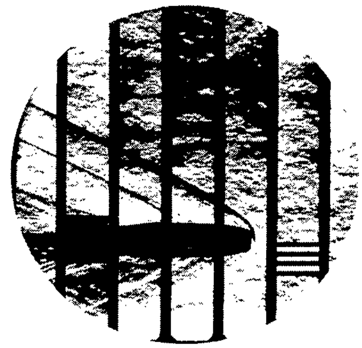


Figure 2.- Details of the escape-capsule model.

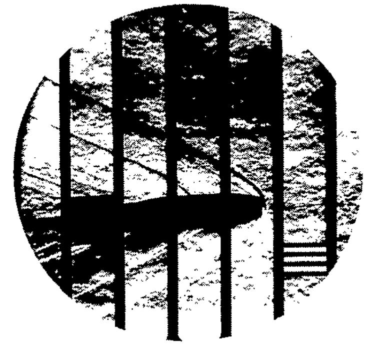


L-97112

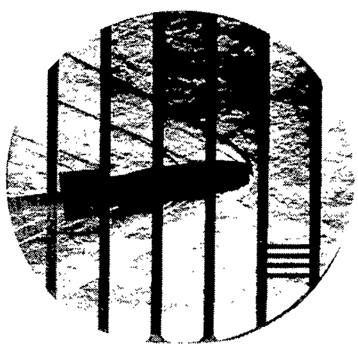
Figure 3.- The escape capsule with stabilizing fins.



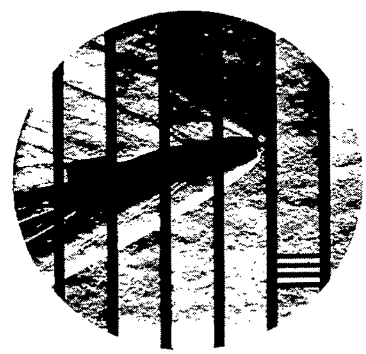
$\beta = 0°$



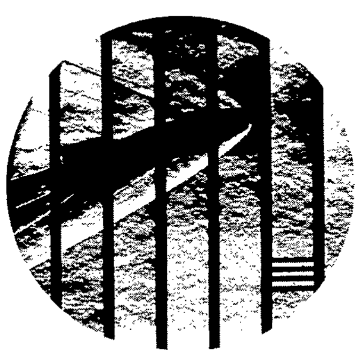
$\beta = -4.1°$



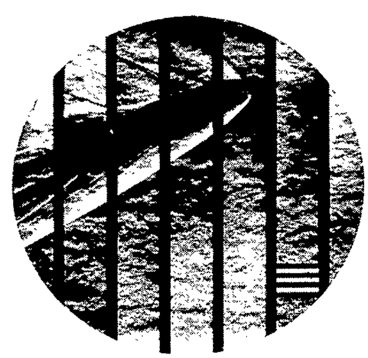
$\beta = -8.1°$



$\beta = -12.2°$



$\beta = -16.3°$



$\beta = -20.4°$

(a) $\alpha = -0.1^{\circ}$; fins on. L-57-2748

Figure 4.- Schlieren photographs of the escape-capsule model at $M = 2.49$ in the Langley Unitary Plan wind tunnel.

(b) $\beta = 0^\circ$; fins off. L-57-2749

Figure 4.- Continued.

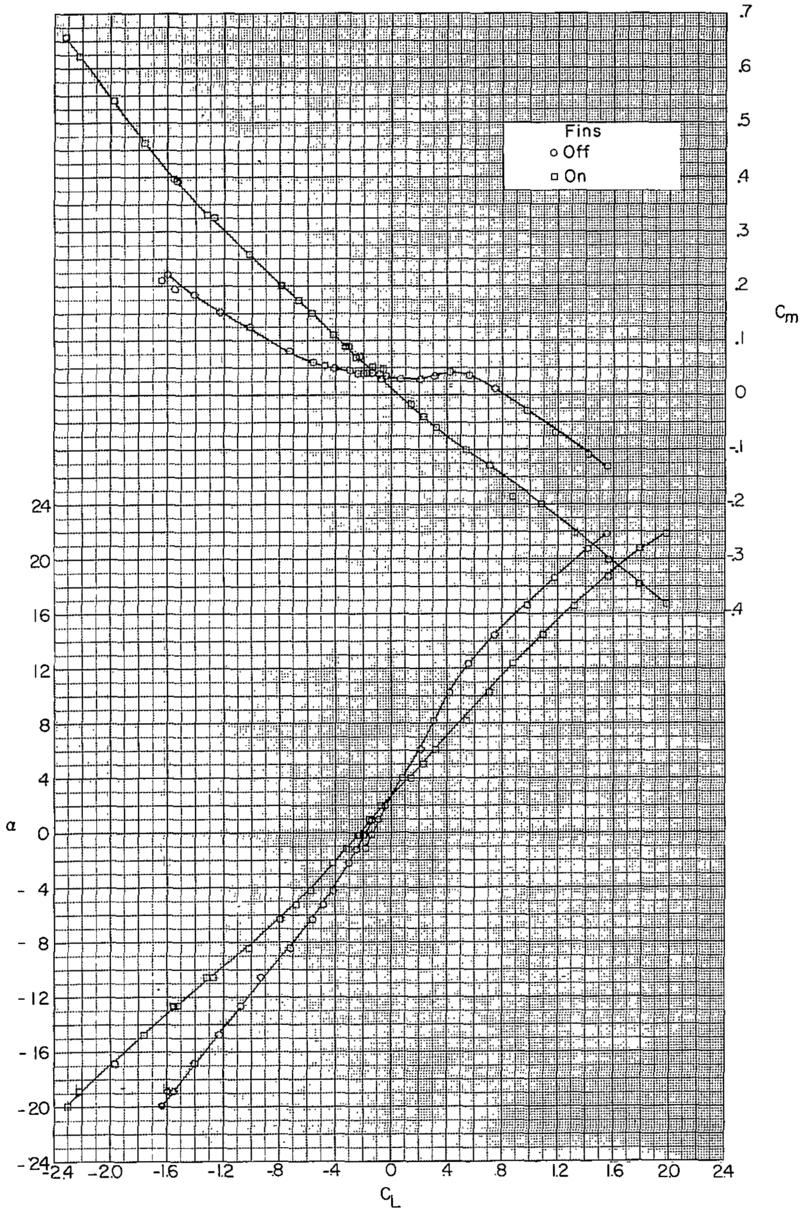
$\alpha = 16.6^\circ$

$\alpha = 20.7^\circ$

$\alpha = 24.9^\circ$

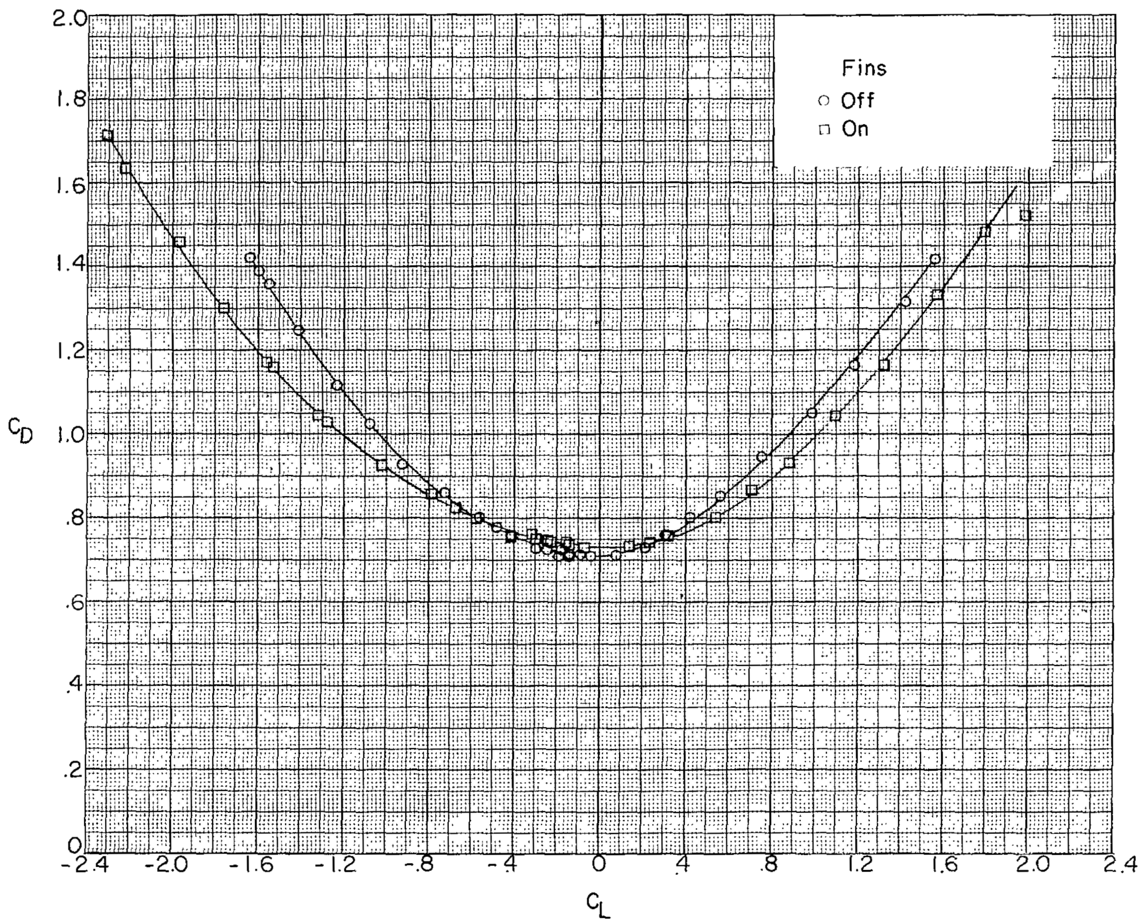
(b) Concluded. L-57-2750

Figure 4.- Concluded.



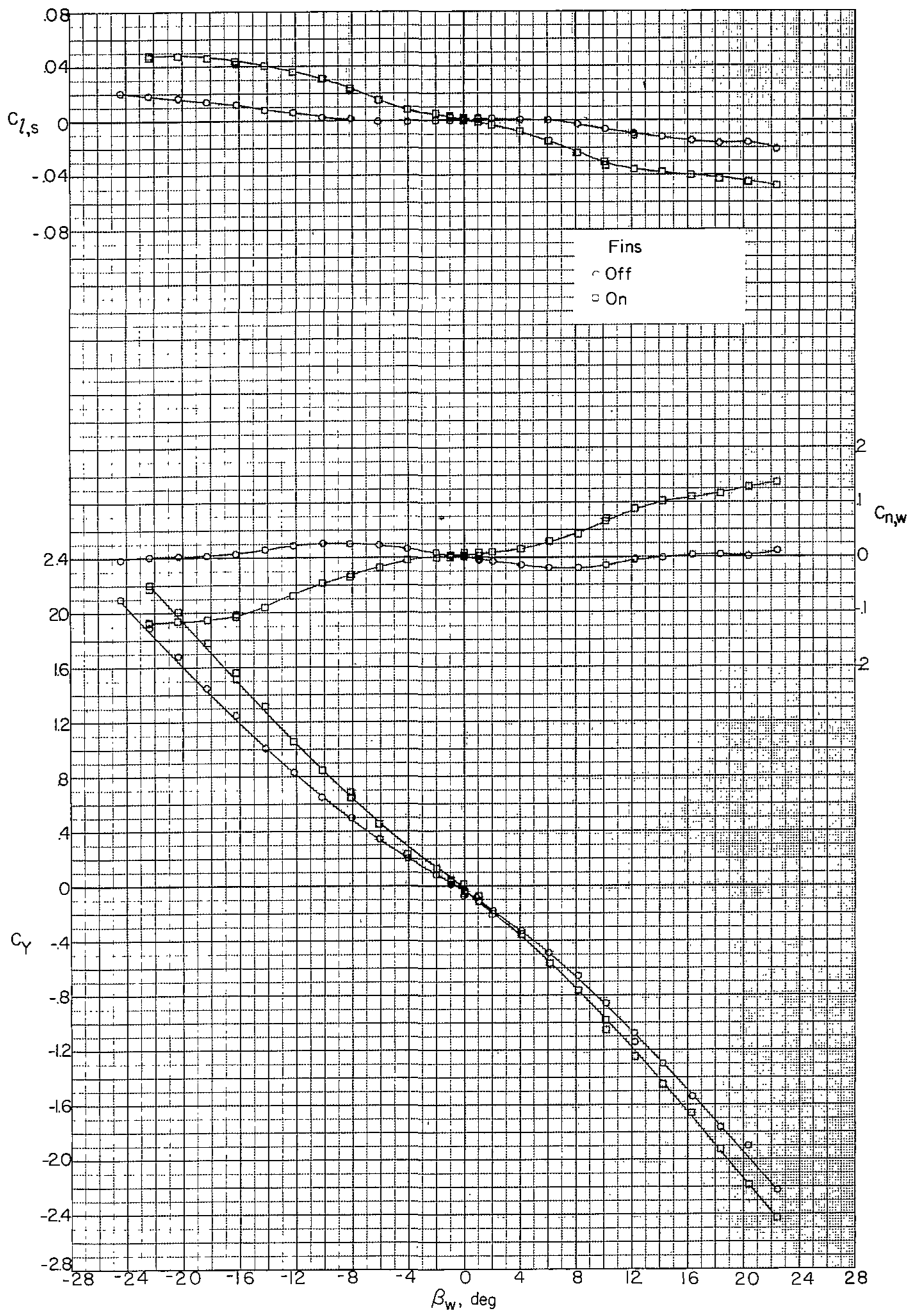
(a) Variation of α and C_m with C_L.

Figure 5.- Effect of stabilizing fins on the lift, drag, and pitching moment characteristics of the escape capsule at a Mach number of 2.49.



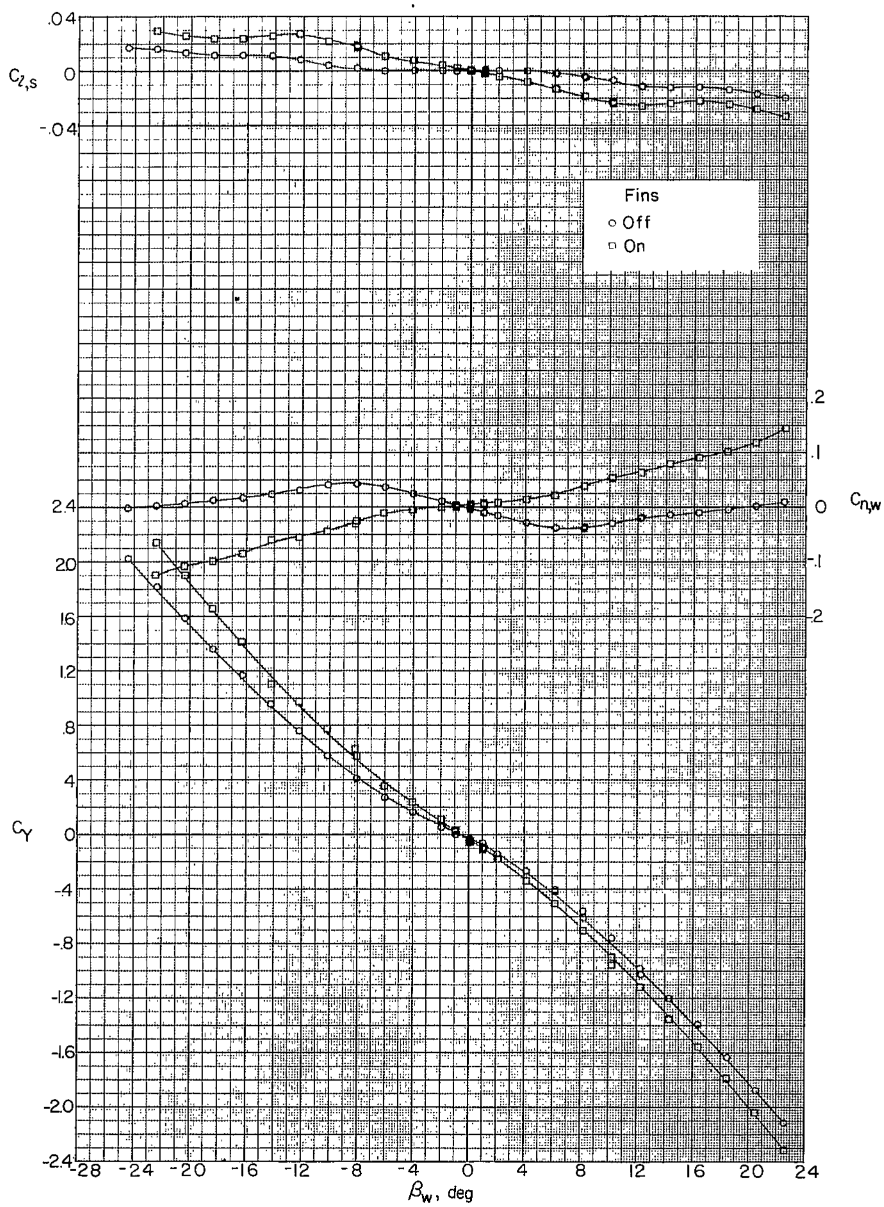
(b) Variation of C_D with C_L.

Figure 5.- Concluded.



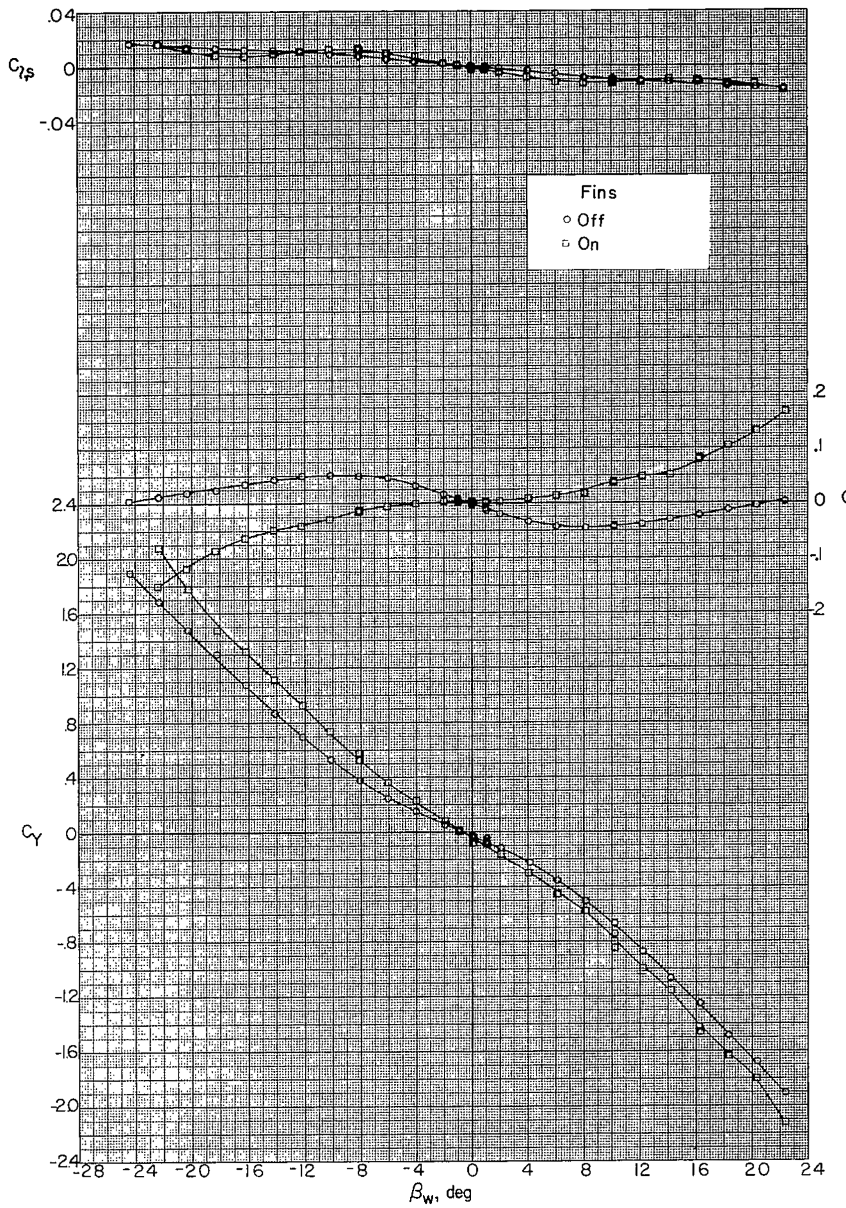
(a) $\alpha = -5.0^\circ$.

Figure 6.- Effect of stabilizing fins on the lateral stability characteristics (referred to the stability axes) of the escape capsule at a Mach number of 2.49.



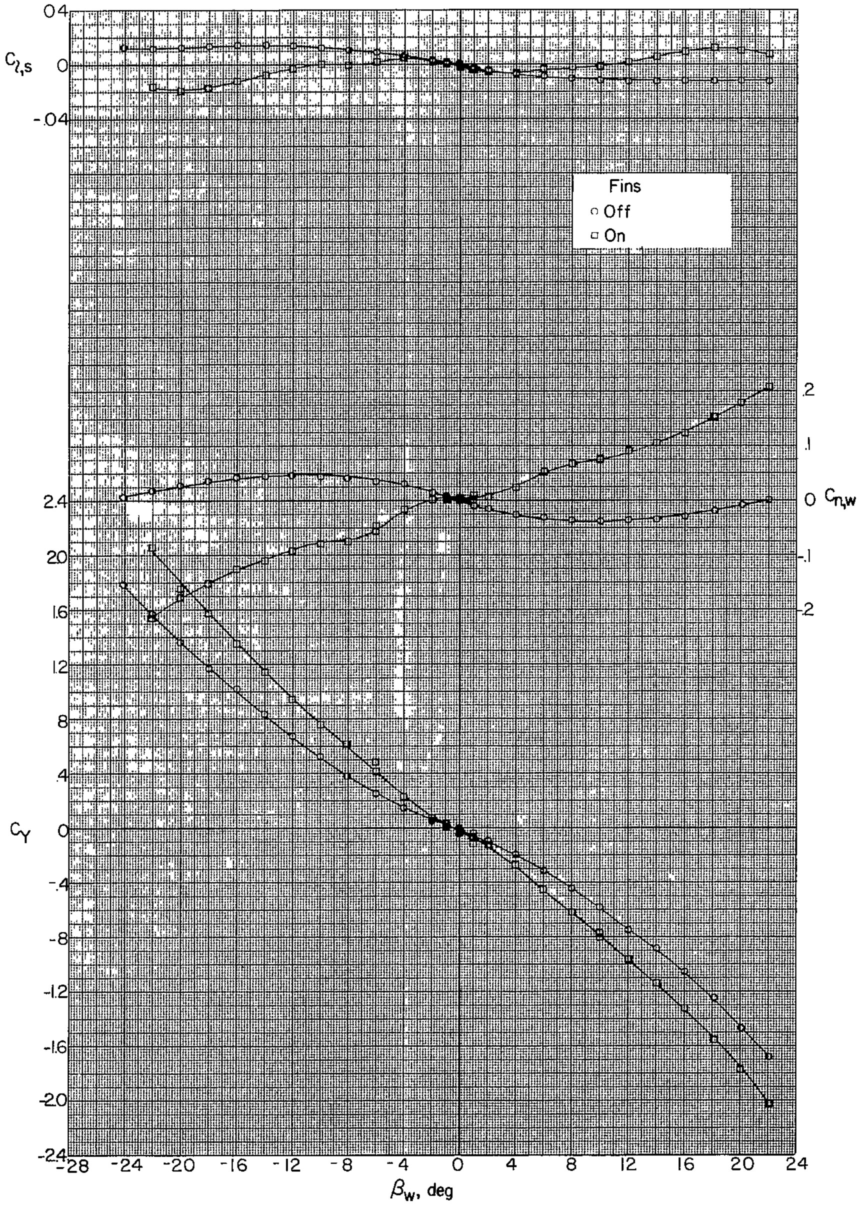
(b) $\alpha = 0^{\circ}$.

Figure 6.- Continued.



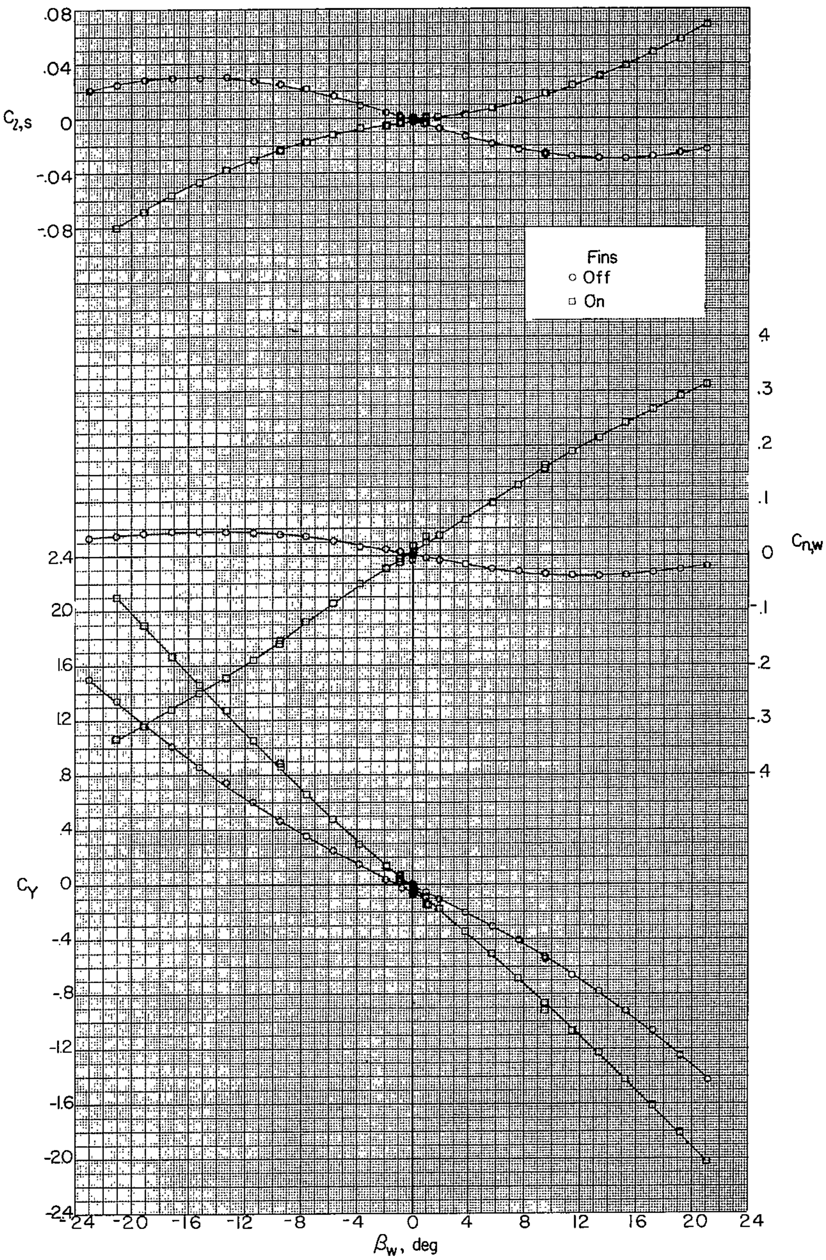
(c) $\alpha = 5.0^\circ$.

Figure 6.- Continued.



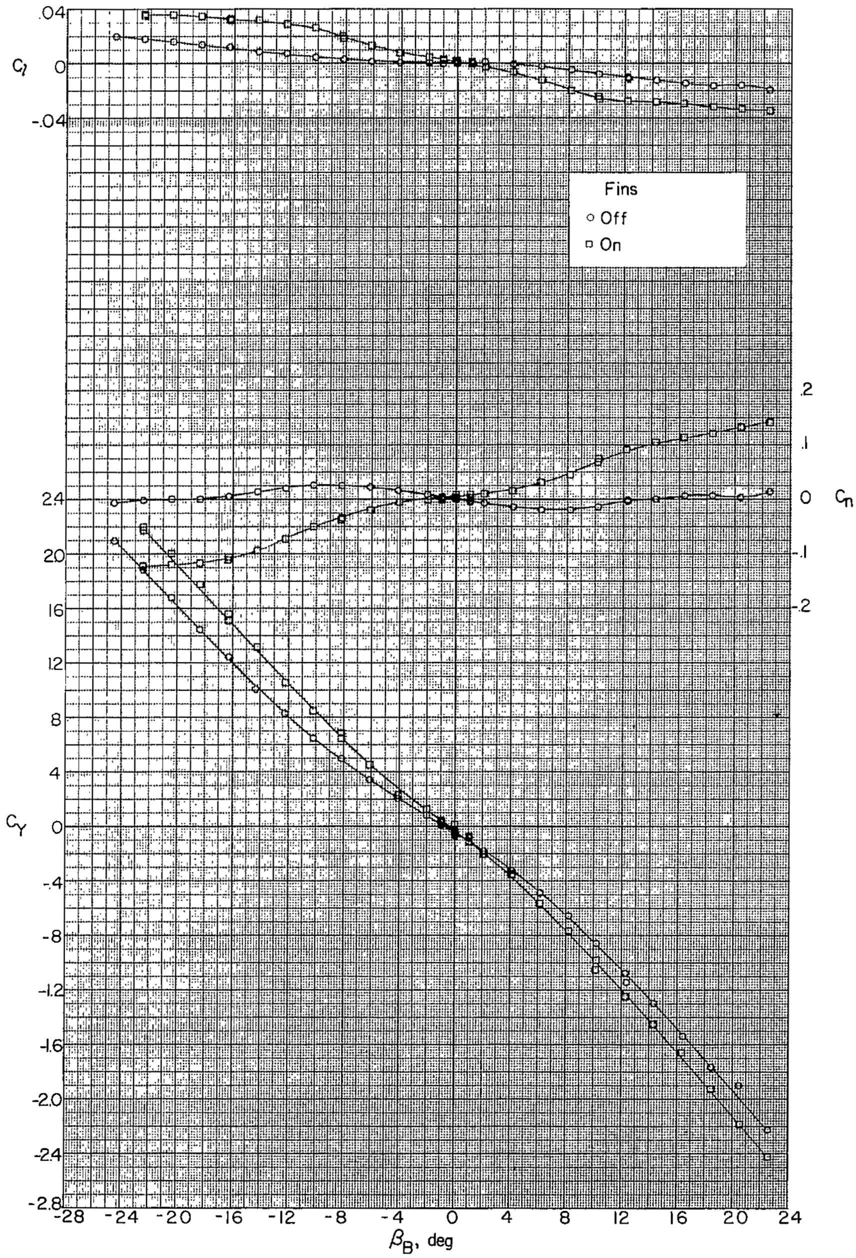
(d) $\alpha = 10.2^{\circ}$.

Figure 6.- Continued.



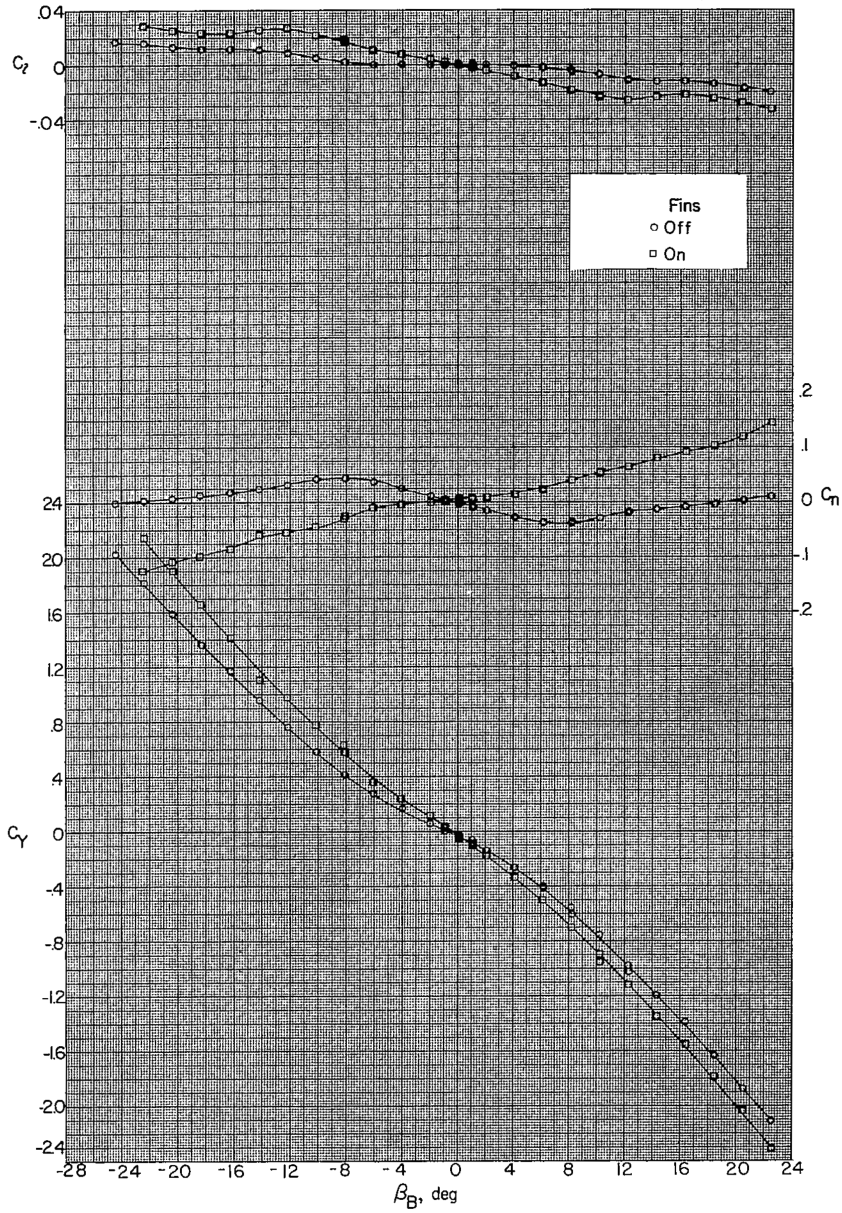
(e) $\alpha = 20.7^{\circ}$.

Figure 6.- Concluded.



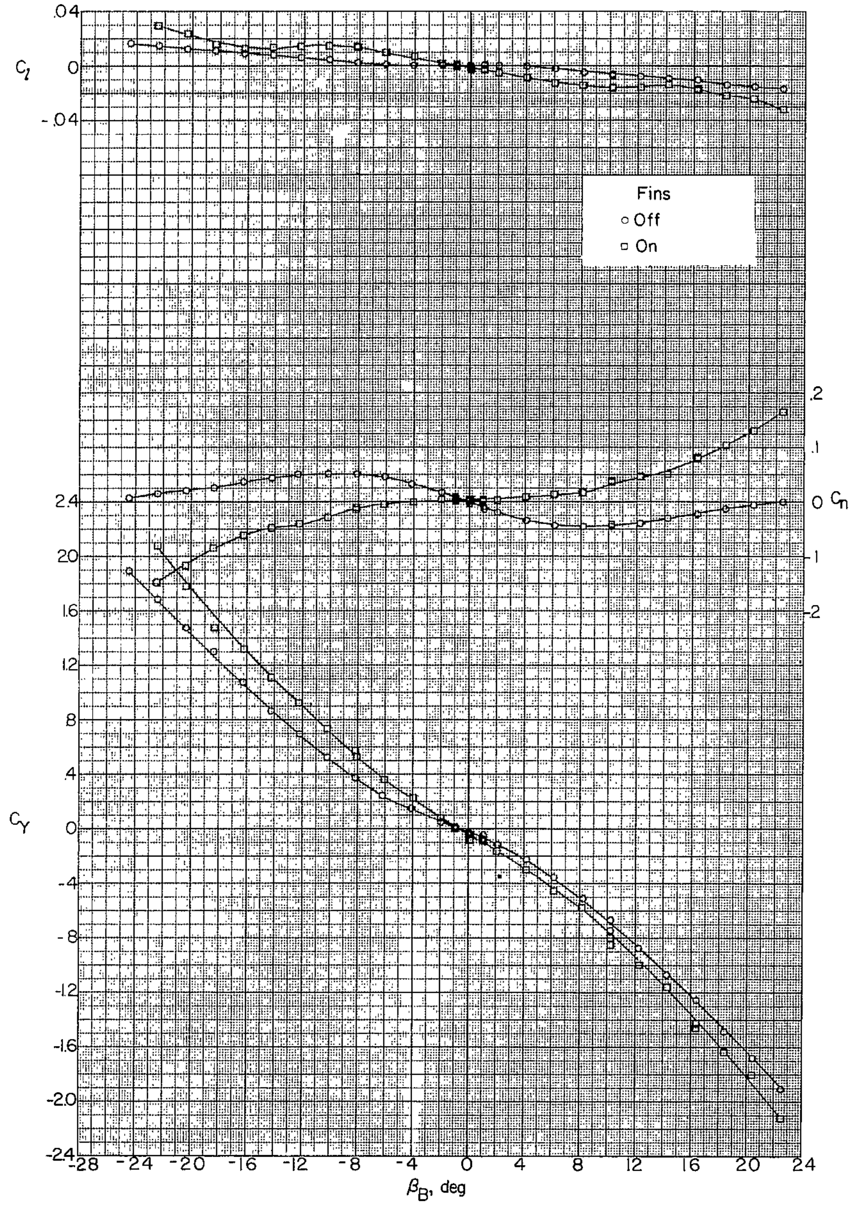
(a) $\alpha = -5.0^{\circ}$.

Figure 7.- Effect of stabilizing fins on the lateral stability characteristics (referred to the body axes) of the escape capsule at a Mach number of 2.49.



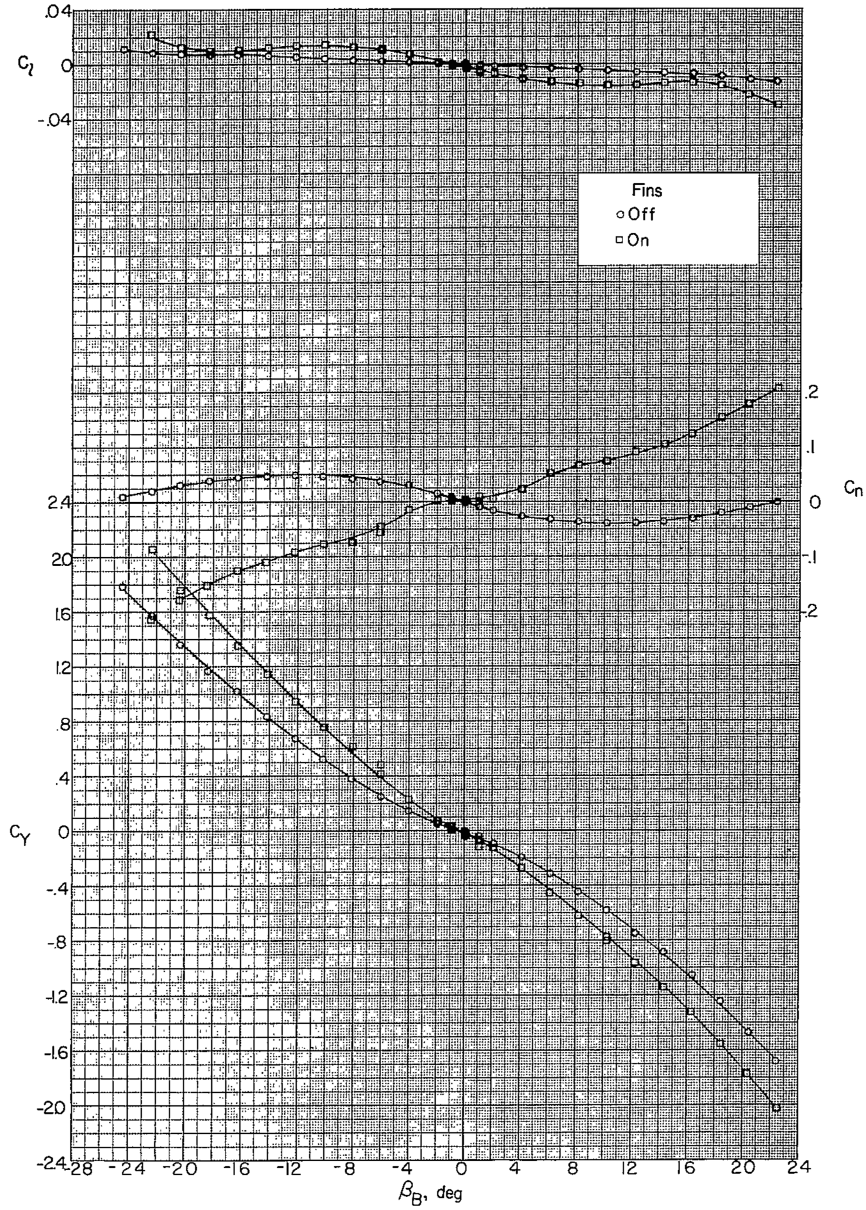
(b) $\alpha = 0^{\circ}$.

Figure 7.- Continued.



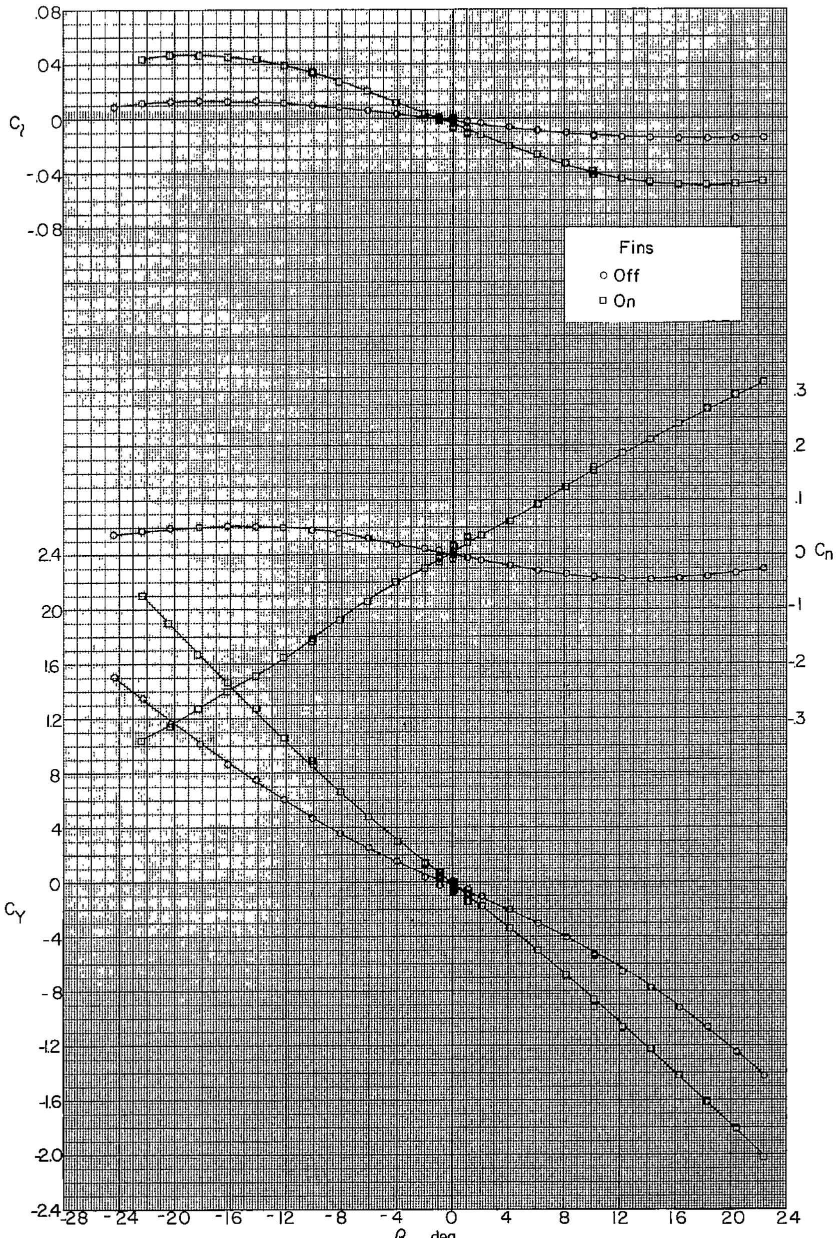
(c) $\alpha = 5.0^{\circ}$.

Figure 7.- Continued.



(d) $\alpha = 10.2^{\circ}$.

Figure 7.- Continued.



(e) $\alpha = 20.7^{\circ}$.

Figure 7.- Concluded.